

SUBJECT: A Review of Bellcomm and LaRC
Studies on Fine Pointing with
an ATM Type System - Case 620

DATE: September 23, 1969

FROM: J. Kranton
R. J. Ravera
P. G. Smith

MEMORANDUM FOR FILE

On September 5 we visited Langley's Stability and Control Section to discuss their comments⁽¹⁾ on Bellcomm's work on fine pointing of telescopes^(2,3) and to learn about their work in this area. We met with W. B. Anderson, N. J. Groom, P. R. Kurzhals (Chief), and J. D. Shaughnessy.

Capability of ATM Type System, P. G. Smith's Work

P. G. Smith in reference (2) reports the results of his work to determine the pointing stability inherent in an ATM type system (that is, two degree-of-freedom hard gimbals). This work was motivated by the possibility of using the ATM for a stellar telescope in the future. Smith concluded that the current ATM has the inherent capability of attaining a pointing stability of 0.1 arcsec for a stellar telescope. He also found that by reducing the sources of error, particularly the gimbal motor breakout torque, a pointing stability of 0.01 arcsec could be attained.

Smith's study did not give detailed consideration to the star sensor or telescope flexibility. However, data on a star sensor from Perkin-Elmer⁽⁴⁾, which we checked, indicates that a sensor adequate for the pointing control system could be developed. The question of telescope flexibility is now being studied and is discussed below.

Work of Langely's Stability and Control Section

This Section became involved in fine pointing control in May of this year. To date they have laid out a research program directed toward developing the technology required for fine pointing systems. They have also developed a single axis analog simulation of the solar ATM. This simulation includes a sun sensor with an assumed deadband of 0.1 arcsec and a rate-sensor with an assumed threshold of 0.1 arcsec/sec. The ATM spar is modelled as a flexible body using MSFC data. So far the work accomplished with this simulation has been to adjust

(NASA-CR-107127) A REVIEW OF BELLCOMM AND
LARC STUDIES ON FINE POINTING WITH AN ATM
TYPE SYSTEM (Bellcomm, Inc.) 5 p

N79-72514

Unclas

00/19 11654

the feedback gains in order to achieve a stable system. They have found, as expected, that the spar wanders within the 0.1 arcsec deadband assumed for the sun sensor.

They plan next to apply crew motion disturbances, which will be simulated as band-limited noise (that is, the output of a filter driven by white noise).

It appears that follow-on work by the Stability and Control Section will address the question of the pointing stability attainable for a stellar telescope with an ATM type system. They are rightly concerned with the fact that the star sensor and telescope flexibility are important items.

Telescope Flexibility

Since any telescope structure will have a certain amount of flexibility, there is the question of what the effect is of the translational motion induced on the telescope support due to movements of the crew. G. M. Anderson has published the results of his work on this question⁽³⁾. He modelled the telescope as a uniform beam supported at its mass center by a spring. At the spacecraft end of the spring, he applied a ramp function of translation which would result from an astronaut pushing off of wall of a rigid spacecraft with impulsive force. This worst case disturbance was used to scope the flexibility problem. Anderson found that with a rigid (stiff spring) support this disturbance produced telescope bending of from 0.5 to 2.0 arcsec, which is clearly excessive. He also found that by reducing the spring constant realistically telescope bending could be reduced to an arbitrarily low level, even below 0.01 arcsec. This result confirmed that translational decoupling using a spring support is effective. However, since the crew motion disturbance was a worst case and not representative of normal crew activity, Anderson's work did not demonstrate the necessity for translational decoupling. His work does indicate, however, that more precise modelling of the telescope, its support structure, and crew disturbances is needed to deal with the problem.

R. J. Ravera and P. G. Smith have also studied the problem of translational decoupling but their results have not been published. They treated crew motion as a random process, just as personnel at LaRC and MSFC are doing. Ravera, using the same uniform beam model as Anderson, found that without translational decoupling telescope bending introduced by random crew motion was small relative to 0.01 arcsec. He also found this to be the case when discrete masses were added to account for the primary and secondary mirrors of the telescope.

Smith has designed structural models of 1 and 2 meter telescopes with 147 degrees-of-freedom. These models include primary and secondary mirrors and an instrument package, and the mechanical supports for these elements. His findings to date do not indicate the need for translational decoupling.

Although the results of Ravera and Smith do not indicate the need for translational decoupling, their investigations are not complete.

Conclusions

In conclusion, based upon what we know today there does not appear to be an insurmountable problem that precludes attaining a pointing stability of 0.01 arcsec with an ATM type system (that is, two degree-of-freedom hard gimbals). We recognize, however, that more analytical studies and simulations will be useful in discovering potential problem areas. We plan to continue our work in this area and we feel that the research plans of LaRC are well thought out and should be pursued. In particular, independent work should be done on

1. in-depth modelling of star sensor noise,
2. developing detailed flexibility models of actual telescope structures, and
3. in-depth simulations of the fine pointing control system including telescope flexibility, star sensor noise, and other sources of error.

Finally, we recognize that the ATM gimbals do not provide fine roll stability and that this question needs study. It appears to be a two part question:

1. requirements, which depend on the type of observations - spectrographic or photographic, and
2. mechanization - fine roll gimbal or image motion compensation.

J. Kranton
J. Kranton

R. J. Ravera
for R. J. Ravera

P. G. Smith
P. G. Smith

BELLCOMM, INC.

REFERENCES

1. Cortright, E. M., Experiment Pointing Accuracies and Stabilities on Manned Spacecraft, NASA, August 25, 1969.
2. Smith, P. G., The Pointing Accuracy of an Orbiting Gimbal Mounted Telescope, Bellcomm, Inc. TM-69-1022-2, February 17, 1969.
3. Anderson, G. M., Dynamic Distortion of a Gimbale Telescope, Bellcomm, Inc., TM-69-1022-3, May 21, 1969.
4. Perkin-Elmer, Princeton Advanced Satellite Study, Volume III, Report No. 8346(III).

BELLCOMM, INC.

Subject: Trip Report: A Review of
Bellcomm and LaRC Studies
on Fine Pointing of Tele-
scopes

From: J. Kranton
R. J. Ravera
P. G. Smith

Distribution List

NASA Headquarters

P. E. Culbertson/MLA
J. H. Disher/MLD
D. L. Forsythe/MLA
T. A. Keegan/MA-2
W. C. Schneider/ML
P. D. Schrock/MLT

Bellcomm

G. M. Anderson
D. R. Hagner
J. Kranton
R. J. Ravera
I. M. Ross
P. G. Smith
W. W. Hough
R. L. Wagner
M. P. Wilson
Department 1024 File
Central Files
Library